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The influence of some acids, bases and salts on an enchytraeid population of a pine litter substrate[1])

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With 1 figure

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1. Introduction

For the culture of greenhouse plants pine litter is a much-used substrate. To obtain an optimal plant growth chemical fertilizers are added. These compounds applied in high doses can be very harmful to an enchytraeid population, especially to *Cognettia sphagnetorum* (VEJD.). A constant dose of 2 g of the mineral fertilizer Alkrisal (18-6-12) per litre of pine litter caused a 90% mortality of the enchytraeid population after one month and 95% mortality after three months (HEUNGENS 1980).

Besides fertilizers the acidity (pH) of the substrate is also of importance. The present experiment was designed to test the influence of pH on a *Cognettia sphagnetorum* population in pine litter. However it is very difficult to affect the pH without affecting at the same time the conductivity (salt concentration). To establish precisely whether the primary effect is acidity or conductivity is rather difficult.

2. Material and methods

At the beginning of December 1980 a test was carried out with a fresh pine litter substrate *(Pinus silvestris)*. The pH was situated between 4.2 and 4.7 with a mean of 4.41 and a standard deviation of 0.15 (n = 8). This substrate was put in plastic containers (10 l ground per container) and treated with acids, bases and with both (= salts).

Table 1. Progress of pH and conductivity ($\mu S \cdot cm^{-1}$) in the test subtrates (*)

After		1/2 month	1	1 1/2	2	3	4 1/2	6 months
control	pH	4.4	4.4	4.4	4.3	4.1	4.4	4.5
	$\mu S \cdot cm^{-1}$	95	95	95	120	185	160	200
nitric acid	pH	3.4	3.4	3.4	3.6	3.6	3.7	3.8
	$\mu S \cdot cm^{-1}$	350	375	380	355	370	360	410
citric acid	pH	3.3	3.6	3.9	3.9	3.8	4.2	4.3
	$\mu S \cdot cm^{-1}$	250	175	120	145	145	150	155
potassium-	pH	3.9	4.0	4.0	4.1	4.1	4.2	4.4
nitrate	$\mu S \cdot cm^{-1}$	1,035	1,030	990	1,080	1,050	1,055	1,200
calciumcitrate	pH	5.7	5.6	5.6	5.2	5.0	4.9	4.8
	$\mu S \cdot cm^{-1}$	185	145	90	170	250	275	350
calcium-	pH	6.9	7.0	7.0	6.6	6.6	6.4	6.7
hydroxide	$\mu S \cdot cm^{-1}$	470	360	235	355	475	335	340
potassium-	pH	7.3	7.1	7.0	6.7	6.3	6.4	5.6
hydroxide	$\mu S \cdot cm^{-1}$	560	430	500	570	680	580	950

(*) mean of 4 observations.

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Seven modalities were obtained with following doses: (1) control; (2) citric acid (6 g l^{-1} substrate); (3) nitric acid (6.5 ml 1 n $HNO_3 \cdot l^{-1}$); (4) potassium nitrate (3 g l^{-1}); (5) calcium citrate (1.6 g $Ca(OH)_2$ + 4 g citric acid l^{-1}); (6) potassium hydroxide (3 g l^{-1}); (7) calcium hydroxide (4 g l^{-1}).

The test was carried out with four replications of 10 l substrate over the following temperature ranges: Dec. 4—9 °C, Jan. 2—8 °C, Febr. 2—12 °C, March 6—16 °C, April 5—18 °C and May 12—21 °C. The humidity was adjusted weekly by means of rainwater. The progress of *p*H and conductivity (Table 1) was achieved by the method of HEUNGENS *et al.* (1975). From Table 1 it can be concluded that KNO_3 also increases the acidity and Ca-citrate the alkalinity. Citric acid was probably converted enzymically (bacterially) by the end of the test. By building up K_2CO_3 potassium hydroxide presented after 6 months a more moderate *p*H. The measurements prove that the buffer capacity of the litter was maintained.

The enchytraeids were sampled after 1—2—3—4$^1/_2$ and 6 months. The samples had a volume of 100 ml and the enchytraeids were collected by means of Baermann funnels. The sample number was 140 (7 treatments × 5 periods × 4 repetitions). *Cognettia sphagnetorum* was highly dominant (> 95 %).

3. Results

The global analysis of variance was carried out on the 140 observations. For that purpose a transformation was effected to obtain a normal distribution of the data. A log (x + 1)-transformation of the number of enchytraeids per 100 ml substrate was used. The result of the analysis of variance is given in Table 2.

Table 2. Results of the analysis of variance after log (x + 1)-transformation of the data*)

	Sum of Squares	d.f.	Mean Squares	F-calculated	F-table (p = 0.01)
Total	98.635,589	139	—	—	
Treatments (T)	80.834,036	6	13.472,3	306.36	3.07
Periods (Time) (P)	4.255,340	4	1.063,8	22.89	3.60
Blocks (B)	0.116,556	3	0.038,9	0.88	—
T × P	8.456,245	24	0.352,3	8.01	2.07
T × B	1.272,102	18	0.070,7	1.61	—
P × B	0.535,090	12	0.044,6	1.01	—
Residual error	3.166,220	72	0.044,0	—	—

*) number of enchytraeids per 100 ml.

From the data of Table 2 it can be concluded that a pronounced significant result was obtained, especially for the treatments, but also for the period. The interaction between both factors was significant. To the contrary none of the factors relating to the blocks (repetitions) were significant.

The arithmetic and logarithmic means, according to the treatments and the period of sampling, are given in Tables 3 and 4 together with the least significant differences.

Table 3 shows that no difference between the size of the enchytraeid population for the three middle periods was stated, contrary to the first and last periods of sampling which differ markedly from the 3 others. At the start of the experiment the population was disturbed by the intensive mixture of the substrate with the applied compounds.

Table 3. Arithmetic and logarithmic mean number*) of enchytraeids per 100 ml substrate according to period of sampling

Period	$\sum x/n$	$1/n \sum \log(x+1)$
After 1 month	38.4	1.010
2 months	58.8	1.417
3 months	70.5	1.403
4$^1/_2$ months	68.2	1.345
6 months	244.8	1.523
l.s.d. (0.01)	—	0.149

*) n = 28.

Besides there was the shock effect of the treatments, resulting in the smallest population at the first sampling. At the last sampling there were counted far more enchytraeids. This can be explained by the higher temperatures at the end of the test and the manner of reproduction of the dominant species *Cognettia sphagnetorum* (ABRAHAMSEN 1972) which normally reproduces asexually through fragmentation (LUNDKVIST 1981). The adaptation to a constant environment which seems to favour asexual reproduction is clear (GHISELIN 1974).

Table 4. Arithmetic and logarithmic mean number*) of enchytraeids per 100 ml substrate according to treatment

Treatments	$\sum x/n$	$1/n \sum \log(x+1)$
control	359.4	2.466
calcium citrate	187.0	2.085
citric acid	79.7	1.697
calcium hydroxide	26.5	1.289
nitric acid	11.5	1.023
potassium hydroxide	8.8	0.762
potassium nitrate	0.2	0.054
l.s.d. (0.01)	—	0.176

*) n = 20.

Table 4 shows that each treatment differs significantly from the others (for $p = 0.01$). It is clear that the applied compounds had a pronounced negative effect on the population density. For example KNO_3 at 3 g per litre substrate destroyed practically completely the enchytraeid population, given that only 0.05% of the control survived this treatment. From the sequence of the toxicity it appears clearly that the population decrease is not due to the *p*H. The population sizes of the HNO_3 and KOH treatments are closest together.

It is known that a high conductivity of the soil solution causes a sharp decrease of the enchytraeid population (HEUNGENS 1980). Since the value of the conductivity according to the treatments is known (Table 1), the correlation and regression between the conductivity of the soil solution ($\mu S \cdot cm^{-1}$) and the population density (number of enchytraeids per 100 ml) may be calculated. For the latter value the logarithmic mean of the 4 independent repetitions (blockscontainers) was taken, thus obtaining 35 pairs (one per 7 treatments $\times$ 5 periods). The 35 pairs of data are given graphically in Fig. 1.

The calculation of the correlation gave a highly negative result ($r = -0.816{,}1$), notwithstanding the application of such different compounds. The confidence level for $p = 0.001$ and 33 degrees of freedom is only 0.533,0. The conductivity is thus responsible for 2/3 of the population density of the enchytraeids.

The regression line conforms to $\log(y + 1) = -0.002{,}092x + 2.240{,}9$. Considering the fact that the normal electrical conductivity of a pine litter soil solution is between 75 and $200 \mu S \cdot cm^{-1}$ we can read on Fig. 1 (or calculate) that between 910—$970 \mu S \cdot cm^{-1}$ only 1% of the enchytraeid population survives and at $1{,}050 \mu S \cdot cm^{-1}$ less than 0.17%.

4. Discussion

The osmotic pressure of a solution of a known salt is usually calculated from the electrical conductivity. Salts, acids and bases can have a toxic effect to plant growth. Besides, the osmotic pressure of the soil solution, which depends on the applied compounds, is closely related to the rate of water uptake. The enchytraeid cells seem also to be very sensitive compared to those of organisms such as nematodes (HEUNGENS 1981) and to a lesser degree mites and collembola (HEUNGENS & VAN DAELE, in press).

LUNDKVIST (1981) found that intensive nitrogen fertilization resulted in a significantly decreased number of enchytraeids. Six months after fertilization there was a decrease of 20%. For a decrease of 20% we need only an increase of $50 \mu S \cdot cm^{-1}$, which is directly reached with a nitrogen fertilization.

Because the ammonium and nitrate nitrogen are susceptible to transformation, uptake and leaching their long-term effect can be very different. Fertilizers moreover have an influence on the food availability for some microorganisms and so a positive influence on the substrate environment.

LUNDKVIST (1981) also stated that liming as well as acidification resulted in a 10% decrease in the number of enchytraeids. Laboratory experiments indicated that growth and subsequent fragmentation rate of *Cognettia sphagnetorum* are lowered by low soil *p*H. This author supposes that the main long-term effect of a changed *p*H on the population may be due to a reduction of the growth rate of *C. sphagnetorum*. In nature where leaching of mineral compounds is possible, the clear-cut effect obtained in the laboratory is not so striking.

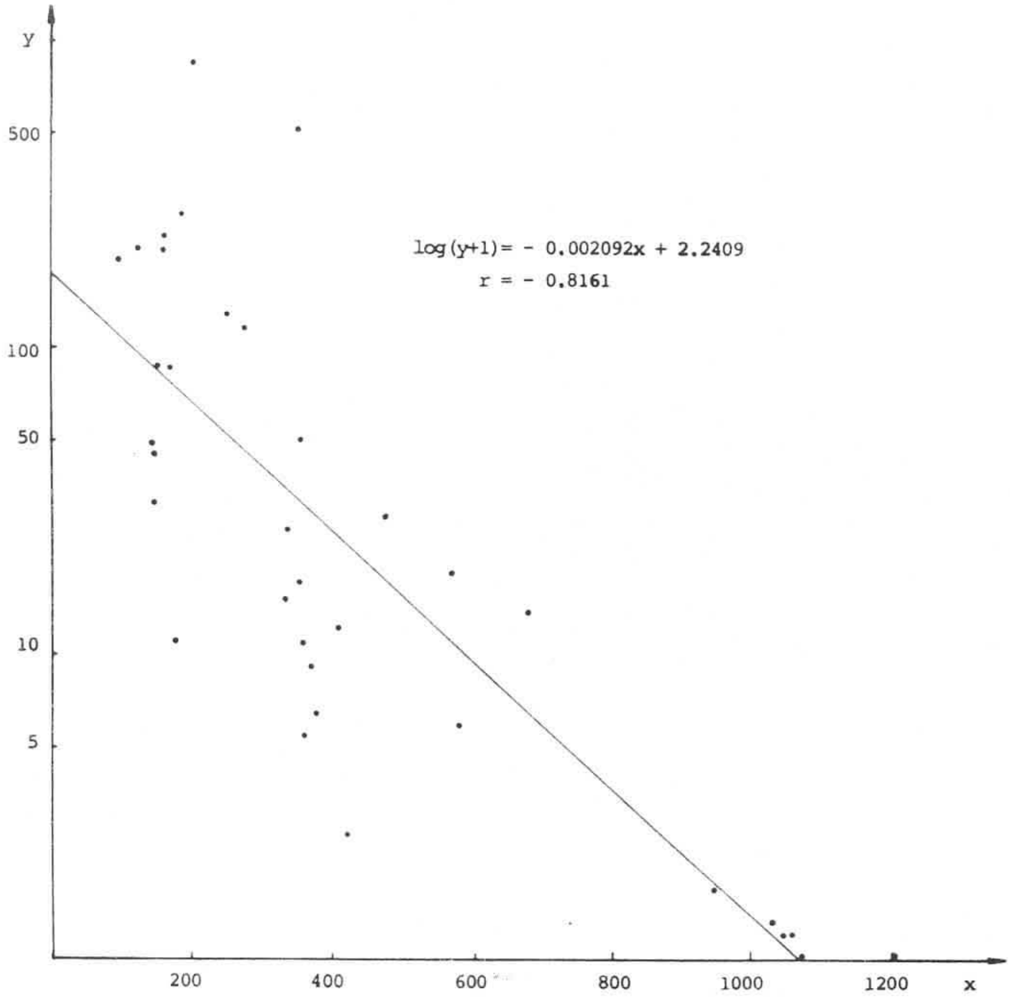

Fig. 1. Regression line between the number of enchytraeids per 100 ml (y-axis) and the electrical conductivity in $\mu S \cdot cm^{-1}$ (x-axis).

If the aim of our experiments had been in the first place the correlation between the *Cognettia* population and a really enhanced electrical conductivity with a good dispersion of the conductivity data between 100 and 1,100 $\mu S \cdot cm^{-1}$ we could undoubtedly realise a correlation coefficient of about —0.95. Yet our aim was the influence of the *p*H.

Enchytraeids and especially *Cognettia sphagnetorum* are striking indicators of the degree of salinity of a soil.

5. Résumé

L'influence de quelques acides, bases et sels sur une population d'enchytréides dans la litière de pin

Afin de connaitre l'influence du *p*H sur la population des enchytréides *(Cognettia sphagnetorum)* de la litière de pin, celle-ci a été traitée en laboratoire avec des acides, des bases et des sels. Les résultats démontrent que l'influence du *p*H sur les enchytréides est non significative comparée à celle très prononcée pour la conductivité électrique du sol. La régression linéaire entre la conductivité et la population des enchytréides est très significative ($p > 0{,}001$) et le coefficient de corrélation négatif (—0,82), ce qui démontre que tous les produits qui font augmenter la conductivité sont nuisibles aux enchytréides.

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Pine litter substrate was treated in the laboratory with some acids, bases and salts to investigate the influence of the *p*H on the enchytraeid population *(Cognettia sphagnetorum)*. The results prove that the influence of the *p*H was markedly insignificant on the enchytraeids compared with the strong influence of the electrical conductivity of the soil solution. The regression line between the conductivity and the enchytraeid population was very significant ($p > 0.001$) and the correlation coefficient highly negative (—0.82) which proves the harmful effect of all compounds which increase the conductivity.

Key words: *Enchytraeidae*, *Cognettia sphagnetorum*, pine litter, *p*H, salt, fertilizer, electrical conductivity, osmotic pressure.